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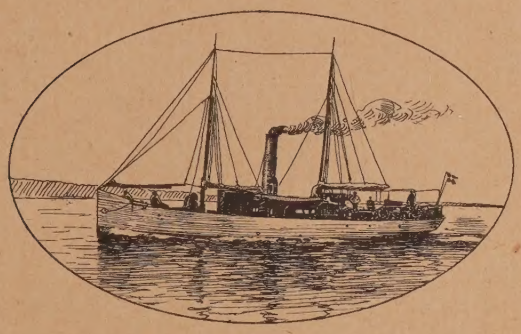
Report

of

The Danish Biological Station

to

The Board of Agriculture.



XIX.

1911.

By

C. G. Joh. Petersen,

Ph. D.

Translated from „Fiskeri-Beretning for 1910".

Copenhagen.
Centraltrykkeriet.
1911.

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The Danish Biological Station.

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Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord.

In 1909 a »Committee to combat the harmful animals of the fisheries« appointed by the Dansk Fiskeriforening, published a short report on this matter, and the Council of the Fiskeriforening submitted a proposal to Landbrugsministeriet that funds might be allocated for this purpose. The matter was sent to me for explanation and this explanation, with but few changes, was as follows.

»The Committee in including 5 animals on the list of harmful animals, namely, the sea-scorpion, stickleback, crabs, star-fish and whelks, have specially relied upon § 40 of the Fishery Law regarding rewards for the bringing of star-fishes to land in the Limfjord, and desire that this § shall be extended to embrace among others the 5 animals mentioned and to apply to the whole of the Danish sea-territory. I may remark to this, that this § is on the whole not well-grounded; its persistence in the law is only due probably to some old regulations for the oyster-dredgers, who were meant to land the star-fishes they fished. This old regulation has never been carried into effect, so that we know nothing at all as to its usefulness. We thus have no available material to build upon, and before we can obtain such, we should proceed experimentally, that is to say, undertake such experiments on the extermination of the harmful animals as will in the course of a few years afford information which would show, whether they have helped to reduce the numbers of these animals or not. It it just as important to obtain the last, negative result from the experiments as the positive; as otherwise it may happen with this as with the artificial hatching of salt-water fishes in other countries, that much money has been spent for a long series of years, but no result has ever been noticed, whether the experiments have been of use or not. I consider that it was a good thing for Denmark, that I at that time opposed such unripe experiments on a large scale and thus saved the State unnecessary expenditure, and instead endeavoured to find some other ways of increasing the quantities of fish in our small waters, namely by the inplanting of young fish from the sea. These results could be controlled; at some places they were an advantage, at others not.

However much I may desire with the Committee to see the numbers of the harmful animals mentioned reduced at many places, since they cannot all be

considered harmful everywhere, I must yet disagree with the Committee regarding the manner in which the end has to be achieved. One thing we must remember, namely, that the fight with these harmful animals is everlasting; the species can never be quite exterminated. For example, howewer much the public have helped to the extermination of the prawn as a useful animal, it has yet not entirely disappeared from any of our small fjords. It is thus a perpetual fight, and we must consider who has to bear the expense in the long run; the only way this can be met is to find a profitable use of the animals in question for industrial or other purposes, as the Committee indeed also suggest; but at present we do not understand how to do this in Denmark. The conditions here are not the same as in other countries, nor can we directly introduce the results from the latter into Danish conditions; these results must first be tested and studied, then perhaps the right man will come who can solve the problem. In my opinion, therefore, it would not be right, as the Committee propose, to use 20,000 Kr. directly in rewards for the harmful animals mentioned indiscriminately and especially not everywhere in Denmark, as it is quite possible, that after a number of years have gone past we will be exactly at the same place as we are now, namely, that we will not know whether it is of advantage to continue or not; provisionally we should certainly keep to experiments in small waters, as the large would assuredly show no result at present. We may remember here, how strongly the war against the rats had to be organised in this country, before there was any hope of achieving anything worth mentioning. The fact is, that it is of no use to destroy a small number of a harmful species, the remainder live and propagate just so much the better and more rapidly; in other words, the stock remains the same every year; only when more are exterminated than are yearly produced, can we manage to reduce the stock, and the fight must be continuous. A wood does not disappear from cutting down the trees; to obtain this result, more must be cut down than grow yearly, and the cutting must be continued.

The rate of propagation of the 5 animals mentioned is however very different, and the same is the case with their biological conditions. If, from my knowledge of these conditions, I were to mention which of them might most easily be combated in our small waters, the whelks would be the first, next the crabs and sea-scorpions and lastly, the sticklebacks and starfishes.

The whelks *(Buccinum)* are not able to swim, either as small or as adult, and consequently cannot spread in this way, and crabs and sea-scorpions do not propagate in several of our small, enclosed fjords; on this account their numbers here might probably be kept down somewhat by a constant warring against them.

On the other hand, I at present consider that the fight with the sticklebacks and starfishes is hopeless in our country.

With regard to the whelks, I have seen this year, 1909, during my investigations in the Limfjord, that it would be quite useless to give rewards for the number of whelks the fishermen bring to land when fishing for plaice; this number namely is too small a part of the stock. Instead of this a special whelk-fishery might be organized here with hive-traps or such like. Such a fishery might well be established. From a couple of motor-boats, each with 2 men and several hundred hive-traps, some thousands of barrels of whelks could be fished

yearly in Thisted Bredning along, and this would probably in time reduce the stock appreciably. The stock in Thisted Bredning may probably be estimated at 20—40,000 barrels of whelks.

On account of the immense harm done by the whelks to the fishes entangled in fishing-nets — both plaice and other fishes in the Limfjord and just in Thisted Bredning — I advise that an experiment with a motor-boat should be undertaken as soon as possible. It would also be desirable here, if the matter could pay itself economically, but even if this were not the case, the money would be well-spent on the experiment. If such a paying enterprise could be started in the Limfjord, similar undertakings might perhaps be begun at other places, but the Limfjord is the right place for the start. We have seen how, from the study of the biology and cultivation of the plaice, practical results were first obtained in the Limfjord; perhaps the same will occur in this case. The reasons for this are of both a biological and legislative nature, and it is not necessary to explain them further here; but as the fjord-exploitation of the Limfjord is already much developed, it is only consistent to endeavour to increase it by means of fjord-administration. My advice is, consequently, that the Board of Agriculture should this year procure a specially equipped motor-boat.

With such a boat we can investigate about the number of barrels of whelks which can be fished in a year and thus, whether it is of any use to go further in the matter by procuring more boats; we would see further, if the people of Thisted Bredning will understand how to make the whelks profitable as food for pigs, fowls and ducks, for which use the whelks seem to be well suited, and lastly, at what price the whelks can be sold.

This year, of course, the work may be restricted simply to the fishing of the whelks and throwing them away; but it will be very unfortunate, if we cannot at the same time make experiments on their utility.

I consider it of great importance, that the matter should be undertaken soon and just in 1910; hive-traps, namely, can only be made in the winter, and the Limfjord is in any case being investigated by the Biological Station this year.

Before I express an opinion as to the possibility of combating the crabs and sea-scorpions, I should prefer to make investigations into the matter from the Biological Station for about a year or so.«

In the winter of 1910 the Board of Agriculture allotted the funds necessary for the Station and the experiment of fishing up the whelks in Thisted Bredning was begun on the 4th of April 1910.

The whole matter of the destruction of plaice in the nets by the whelks had been naturally under my observation in several previous years. It was thus in accordance with my wishes that Dr. Th. Mortensen, the assistant at the Biological Station, in 1895 carried out the enquiry mentioned on p. 46 of the Committee's communication, in order to ascertain how many of the plaice caught in the nets are destroyed in one to two nights; but I was not at all clear, as to how we should organize an attack on the whelks. It was not until 1909 that I began again to examine into the matter, more particularly, in connection with other

investigations regarding the inplanting of plaice, which has now been set on foot on a large scale.

Some few figures will explain better than many words how the matter really stands.

Over large areas of the Limfjord, especially in the central parts, two species of predatory whelks occur in great quantities; one a large form, the common dog-whelk or the »Konkylier« of the Limfjord *(Buccinum undatum)*, and a smaller, *Nassa reticulata*. They are both shown in fig. 1. They have long snouts furnished with sharp teeth, by means of which they can tear up all the flesh they can get hold of. Their mode of attacking the plaice is to gnaw a hole in the skin and put

Fig. 1.

their snout through this hole; they then devour all the muscular tissue, leaving only the skin and bones. The slow-moving whelks however cannot seize the plaice when swimming freely, but when the plaice are caught in the gill-nets (see fig. 2), which always reach to the bottom, they are often so entangled or so enfeebled, that they sink quite down to the bottom and lie quietly; they thus become an easy prey for the whelks. In figures 3 and 4, several whelks are seen attached to the plaice just brought up in the nets; the latter are dead in the first place, but they are also partially devoured by the whelks and of no use as human food. In fig. 3 at least 3 *Buccinum* are seen and 2 in fig. 4 together with a starfish *(Asterias)*. The small whelks, *Nassa*, attack the plaice in a similar way and, on account of their greater numbers, are perhaps still more harmful than the large. On the other hand, the plaice are not so much in danger of the starfishes *(Asterias)*, as the latter ordinarily only get time to suck at them outside on the skin, but they also might kill the fish. It can readily be understood, that the whelks do an immense amount of harm in waters where the fishery

and prices are based on the capture of living plaice, especially when the fish are caught in nets which stand for many hours (not in seines), in accordance with the bye-laws of the Limfjord for the greater part of the year. In the case of the trawls, which are quickly drawn up, the whelks do not get time to attack the plaice; but the trawl has other drawbacks, which, however, need not be further discussed on this occasion.

The whelks find the plaice and their food on the whole by means of their finely developed sense of smell. They also attack all other fishes fixed in the nets; in a few hours 10—20 whelks will often fix themselves on to a plaice or other dead fish on the bottom of the sea. The whelks are so numerous, that some

Fig. 2.

hundreds, both large and small, can be fished in 24 hours in a hive-trap with a piece of split cod as bait. We may imagine, that in the centre of the Limfjord several whelks occur on an area no larger than the floor of a room; as they are able to crawl rather rapidly, we can understand how, in the course of a few hours, they might easily find a dead fish lying on the bottom and devour the muscles. On the other hand, they will not touch rotten fish; experiments with soiled bait in the hive-traps have clearly proved this. Sometimes dead fishes can be found in numbers on the bottom of the Limfjord; this was the case in 1909 in the spring, when a great number of eels had been frozen dead in the winter; they were rotten before the whelks had any desire to feed, but I have never seen anything similar in the summer; everything eatable which sinks to the bottom is evidently quickly devoured at that season.

It is very difficult to find out, how great is the number of net-entangled plaice which are devoured by the whelks throughout the year, as this depends on so many circumstances. For example, it is especially in the warmest summer

Fig. 3.

months, that the worst attacks of the whelks take place; but the amount of the damage done daily by the whelks depends greatly on the way fishermen deal with their nets. If they let the nets stand out for 24 hours, most of the fishes attached in it are often devoured, and if a storm rises which prevents the nets being taken up just one single day, so that they remain out 48 hours, practically everything is destroyed. If, on the other hand, the fishermen attend to the

Fig. 4.

nets both morning and evening, as is now often the case, for instance at Thisted in the summer, not nearly so much harm is done, and if they use the method of beating the water in the daytime and thus have the nets out for only a short time, almost no harm is done. But this mode of fishing requires the fishermen to remain uninterruptedly by their nets — for which tolerably fine weather is necessary, so that it is not easily carried out with sufficient profit. We may reckon, however, that all in all the attacks of whelks lead to a loss of $^1/_3$rd of the year's catch in the central parts of the Limfjord; consequently, the damage done is very considerable, and on account of this I have made great efforts to find

Fig. 5.

a suitable use for these whelks, which might perhaps make the fishing of them pay itself and thus be carried on without special support, for example, from the State.

The whelks, the large *(Buccinum),* are acknowledged to be an excellent bait for eels in summer and for cod in winter, and during my investigations this year a part also has been sold to fishermen in Thisted, for use in the eel-fishery; but the local use is too small, when many whelks are fished. Experiments have also been made with the salting of the whelks, taken out of their shells, but on the west coast they were refused owing to the salt making them too hard. I have sent whelks slightly salted to Norway, where salted mussels *(Mytilus modiolus)* and cuttle-fish are known to be much used for bait; but this experiment did not succeed either; it appears that the whelks require so much salt to keep, that it makes them too hard. Next I tried solutions of formaline, and though experimental fishing for cod gave much fewer fishes per 100 hooks with such bait in the Limfjord than with fresh whelks, it is possible, that these prepared in formaline might be used on the west coast, where the fishermen are usually obliged to use salted, not fresh bait. If numbers of whelks could be fished during the

cold season — which however was proved impossible by the experiments with hive-traps — they could be used in great quantities on the west coast. There the fishermen use immense quantities of living mussels, which are fished in the Isefjord or in the eastern part of the Limfjord and can be taken there in an almost unlimited number.

Thus I have not been able to get the whelks used in sufficient quantities in the summer. To investigate whether they might possibly be used for other purposes, for example, as food for man, pigs, fowls etc., I have had them tested by Professor K. Rørdam, and he reports that the whelks dried at 100° contain about 79 % shell and ca. 21 % soft parts — thus, only 1/5th. Of this fifth, however, 6/10ths consist of albuminous matters or related nitrogenous compounds. As the weight of the living whelks is reduced on drying to somewhat under the half, it is seen that the predominant ingredients are lime and water.

Fig. 6.

The large whelks fished in England are eaten in great quantities, for example in London, but I consider it impossible to get them used in this way in our country. On this account I endeavoured to get them prepared as food for fowls or dogs at one of the Copenhagen factories, where such food is made; but as the whelks became rotten so quickly in the warm season that the steamers refused to take them on board, this experiment also failed.

This rapid decomposition of the whelks in the warm season prevents any use of them except locally, and I considered it inexpedient and too expensive at the present stage of the matter, to have a drying-factory built in Thisted. Nor have I tried on a large scale to get them cooked and used as pigs' food, as experience has shown that the removal of the shells must be performed with great care to prevent the stomachs of the pigs being wounded by the sharp pieces of shells, especially by the central spiral inside the shell; this is difficult to remove except by using the fingers to every cooked and crushed whelk. The result is, that all these experiments, which have taken up much of my time, have not succeeded, at least for the time being. Apart from the local use of the

whelks as food for fowls and ducks and as bait, I can recommend nothing at present with certainty. But in Thisted the ducks and fowls which live by the harbour, like to eat the whelks brought to land by the fishermen; I have bought and eaten one of the ducks fed in this way; the taste was not in the least disagreeable, like ducks fed on fishes; the reason being, that the whelks contain but a small proportion of fat.

I may now turn to a discussion of the experimental fishing undertaken in 1910, to give information regarding the number of barrels of whelks, which might be fished in Thisted Bredning from a motor-boat with 2 men.

In 1909, for the purpose of obtaining whelks for salting and for other

Fig. 7.

investigations, I had procured ca. 50 whelk hive-traps, bait-traps as they were called in the Sound, where in earlier years (in the eighties) they were used for obtaining bait. This fishery has now almost entirely ceased there, it is said for want of whelks; nor do I know of other places in the country where the method is still used. These whelk hive-traps are represented in fig. 7, one hanging outside the boat ready to be sunk down to the bottom. They are made of willows and have a funnel-shaped opening et each end; one of the ends is loose, to be taken off when new bait has to be placed inside and the entrapped whelks taken out. The traps must have a weight to make them sink and lie steady, or the whelks will not enter. They are furnished with a rope, which at the surface of the water ends at a wooden buoy, so that the traps can be found again. It was at once found, that it was difficult in the Limfjord to buy bait for these traps. Fresh fish, dried fish, salted fish were all too expensive. I then ordered second-class, but fresh, split cod through an Icelandic firm; it cost but some few øre per pound and turned out to be good. Tainted split cod, however, which I once got

Fig. 8.

in the Limfjord, was of no use; it smelt badly and the *Buccinum* would not touch it; *Nassa* however entered the traps but only in small number. Fresh but unsalted cod seems to be the best bait of all, but as a matter of fact it is dear in these fjords. To economize with the bait, the split cod, which is otherwise rapidly devoured by the whelks so that the traps catch no more, the pieces of split cod were enveloped in a strong steel wire through which the snouts of the whelks could not penetrate. The bait could then last for some days in spring and the trap continue to fish; as soon as the water gets warm, however, the bait must be changed almost daily or it will rot. During the latter period the steel wire was given up; but, to keep the bait from the whelks as long as possible, the pieces of split cod were hung by a wire under the roof of the trap, thus away from the bottom. In this way we managed to keep the bait from being eaten too rapidly. In 1909 by means of these traps we were sometimes able to procure sufficient quantities of whelks, often some barrels full; but as we could not look after this whelk fishery constantly, we could not draw any conclusions from our fishing in 1909 as to how many barrels a boat, only occupied in this fishery, can fish in a year. Sufficient information however was obtained to serve as a basis for the start of such an experimental fishery in 1910.

A suitable motor-boat, such as is shown in figs. 5—7, was procured; it was furnished with a small davit and with a bollard on the motor, as shown in fig. 7, for hauling up the traps; two fishermen from the Limfjord were engaged, partly at fixed wages, partly paid, first 10 later 20 øre for each barrel of whelks of ca. 190 Pd. The fish-exporter Ottesen in Thisted was the corresponding manager of the boat, and on the 4th of April 1910 the fishery could begin.

The boat had ca. 240 whelk-traps at its disposal; they were all put out, but they were not all attended to every day; storms often broke off the fishery.

On p. 13 a list is given of the number of barrels of whelks, daily fished from the 5th of April to the 8th of November, on which day I stopped the fishery.

Whelk fishery in Thisted Bredning from 5. April to 8. Nov. 1910.

Date.	Whelks; ½ bushels.	No. of traps examined.
April.		
5	6	50
6	2	
8	3	25
9	5	60
11	2	40
12	8	90
15	6	75
16	5	75
18	8	100
21	3	52
23	5	60
25	4	45
26	10	100
27	12	80
28	16	90
30	2	18
April 97 ½ bush.		

Date.	Whelks; ½ bushels.	No. of traps examined.
May.		
1	12	75
2	13	85
3	20	100
4	10	45
5	21	85
6	4	100
7	8	34
9	18	90
11	15	60
13	13	28
14	28	100
16	28	80
17	30	110
18	30	100
19	4	12
20	25	80
21	22	75
24	5	25
25	12	45
26	7	20
28	12	35
29	34	115
30	25	71
31	28	60
May 424 ½ bush.		

Date.	Whelks; ½ bushels.	No. of traps examined.
June.		
2	46	120
3	25	60
4	50	120
6	42	100
7	51	120
8	50	120
9	60	160
10	58	170
11	23	60
13	50	120
14	49	120
16	52	120
17	46	120
18	54	120
20	48	120
21	25	60
22	48	120
23	32	80
24	48	120
25	50	120
28	44	120
29	46	100
30	48	120
June 1045 ½ bush.		

Date.	Whelks; ½ bushels.	No. of traps examined.
July.		
1	42	120
2	52	120
4	46	120
5	45	120
6	50	120
7	38	90
9	46	100
11	40	100
12	48	120
13	25	75
14	48	120
15	32	90
16	52	125
18	56	130
19	16	65
21	14	100
22	11	90
23	10	80
26	18	100
27	34	125
28	58	130
29	54	110
30	50	130
July 885 ½ bush.		

Date.	Whelks; ½ bushels.	No. of traps examined.
August.		
1	54	130
2	26	100
3	14	110
4	1	60
6	14	100
8	42	130
9	45	135
10	48	130
11	30	110
12	35	90
13	48	120
15	46	125
17	45	130
18	9	40
19	23	65
20	24	80
22	16	98
23	18	110
24	36	130
25	10	60
26	35	130
27	15	55
30	13	60
31	32	120
Aug. 679 ½ bush.		

Date.	Whelks; ½ bushels.	No. of traps examined.
Septbr.		
1	28	120
2	28	110
3	8	55
5	15	100
6	18	120
7	25	120
8	26	130
9	20	120
10	12	130
12	15	120
13	15	130
17	11	85
19	8	90
20	15	110
21	23	130
22	14	70
26	25	130
27	23	130
28	15	70
29	22	110
30	10	60
Septb. 376 ½ bush.		

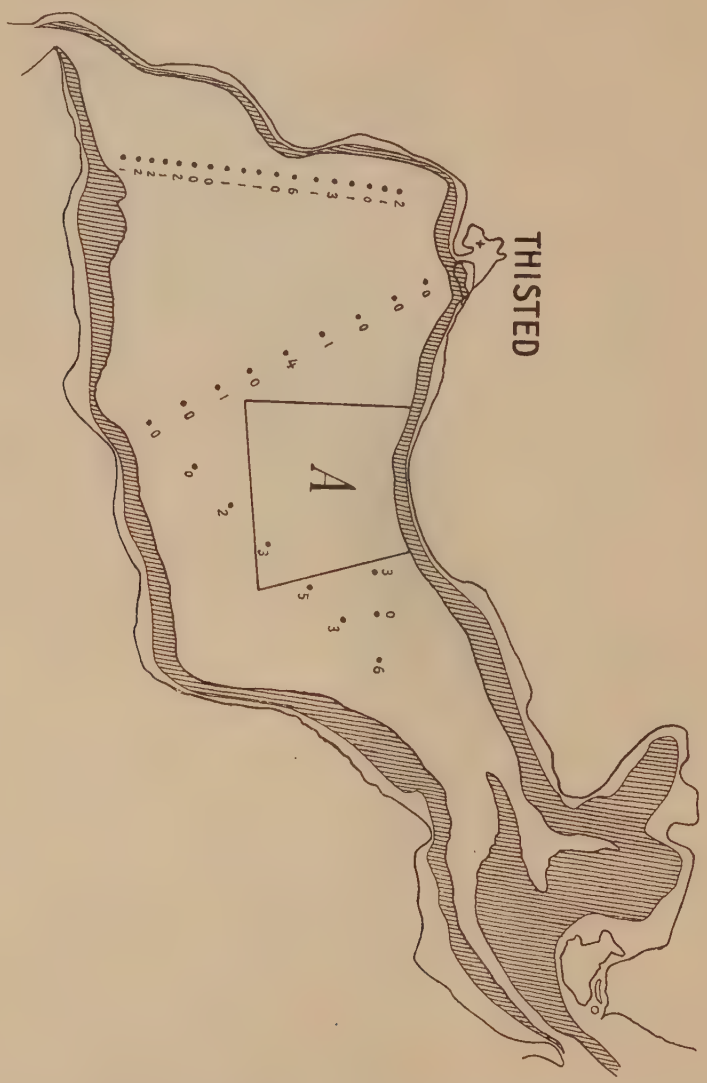
Date.	Whelks; ½ bushels.	No. of traps examined.
October.		
3	5	30
5	15	100
6	18	100
7	22	110
8	13	80
10	23	130
11	22	120
12	12	65
14	28	130
15	17	100
17	25	130
18	13	80
19	15	80
20	3	20
21	8	60
25	15	100
26	18	100
27	14	100
29	10	100
Octb. 296 ½ bush.		

Date.	Whelks; ½ bushels.	No. of traps examined.
November.		
2	10	80
3	10	80
4	5	60
5	8	60
8	10	60
Novb. 43 ½ bush.		

April.....	97 ½ bush.
Maj.....	424 -
June	1045 -
July	885 -
August	679 -
September..	376 -
October	296 -
November..	43 -
Total	3845 ½ bush. whelks.

or ca. 480 barrels
or 91,200 Pd. at 190 Pd. per barrel
or $45_{,6}$ tons of whelks = the coal bunkers of the »Sallingsund« filled 8 times with whelks.

As shown by the table of the daily and monthly hauls of whelks, the fishery was small in the month of April, increasing in May and most abundant in June, in which month 1045 half-bushels (»Skæpper«) of whelks were fished. It



Thisted Bredning. Number of Buccinum. 34 stations with tbe 1,2 m² bottom-sampler. The area fished with hive-traps is indicated at A.

looked as if July would be a good month, but from the 19th to the 27th of July the fishery was very bad; a phenomenon which occurred simultaneously with a great mortality among the plaice caught in the nets; not that these were all attacked by the whelks, but many, though untouched by the whelks, were nevertheless dead in the nets. I imagine that both phenomena were connected with the specially

intense warmth of this past summer. In August and to the middle of November the fishery decreased, and in October it gave but 296 half-bushels.

To gain an idea of the quantities of whelks caught in the Bredning during this fishery, reference may be made to fig. 8, which shows a large heap of whelks thrown up on the beach east of Thisted harbour. This heap only represents however the fishery of ca. 8 days in the summer. The whelks were deposited here to die; they decomposed very quickly and spread an intolerable stench in the neighbourhood. As mentioned, a part of the whelks fished was also used as bait and as food for fowls; but only a small part of the quantities fished could be used in this manner in the summer time.

It soon became clear, that all the 240 traps could not be attended to every day; this took too much time; consequently, we let them remain out on an average for 2—3 days before taking them up; in this way more were caught per trap each time than otherwise would have been the case. As expected, it was necessary each time to move the traps ca. 10—20 fathoms or they fished less; evidently a sign that the stock of whelks was reduced when the traps remained at one place for a couple of days. After some search in the Bredning we found that the majority of the whelks occurred in the eastern part of Thisted Bredning. All the traps were later put out here in 2 long rows at distances of ca. 15—20 fathoms between each; as these rows were constantly mowed each time they were attended to, a not inconsiderable area of the Bredning was fished over in this manner, probably $^1/_7$th of that part of the Bredning which is outside the 6 meter line and in which the majority of the whelks live (see Chart p. 16). To investigate how much the stock was reduced in the summer at the places fished over, some traps were sunk here; it then proved, that the catch in these was only $^1/_3$rd of what was fished immediately. We cannot conclude from this, however, that $^2/_3$rds of the whole stock there was really fished away; we know, namely, that not all the whelks go equally readily into the traps. The experiments were made during the warm period, in July, however, when the whelks were taken in greatest quantity; but we cannot know for certain, whether they will all try to enter the traps at this period.

So much can therefore be said with certainty, that we have not fished away all the whelks on $^1/_7$th of the area of the Bredning.

To form any judgment of the utility of the whelk fishery generally, however, it is of the greatest importance to know the approximate quantities of whelks found in the whole Bredning; if, namely, but a small part of the number is fished away yearly, the stock will probably with but little difficulty be able to replace it, and thus nothing lasting is attained.

Already in 1909, before it was quite decided to undertake this whelk fishery, I had arranged several experiments to test this question.

In our experiments made for other purposes to determine the actual number of animals per m^2 (□ meter) in Thisted Bredning, a bottom-sampler was used with a spread of $^1/_{10}$ m^2. In 1909 100 stations were investigated with this bottom-sampler, and the result obtained was 1,3 *Buccinum* per m^2. With regard to *Buccinum*, however, the numbers obtained by means of this bottom-sampler are so

small, that we cannot trust them. Another bottom-sampler, with a fishing-capacity of 1,2 m² was then constructed and used in the investigation of 34 stations (see Chart, p. 14) scattered over the whole area of Thisted Bredning outside the 6 meter line. The catch with it was 53 *Buccinum,* somewhat evenly distributed over the whole area, but in the eastern part the number was distinctly greater, just where in 1910 the most whelks were also found. This series of stations also gave 1,3 *Buccinum* per m²; but I must consider it a chance, that the numbers for both the large and the small bottom-sampler show just the same result, 1,3; the reason is, that the small one also takes quite small *Buccinum.*

I would not trust this apparatus alone either and arranged for a diver to go down to the bottom at different places in Thisted Bredning, to investigate how many *Buccinum* he was able to find on a definite area; a method I had earlier used in the oyster investigations. The area investigated by the diver was determined from the anchored boat by the length of the air-tube, but also in another manner, by measuring an area of the bottom with a line. *Buccinum* however was not so easy to take as the oysters; they are more buried in the soft bottom and only appear when the diver has disturbed the bottom with his feet; they collect specially in the foot-prints.

At one place the diver investigated ca. 106 m² and took 100 *Buccinum*
- a second » » » » 36 » » » 128 »
- - third » » » » 106 » » » 70 »
- - fourth » » » » 106 » » » 97 »

At the last two places the diver was of the opinion that he had only caught 1/3rd of the *Buccinum* present there. If we therefore multiply the last two numbers with 3, he observed altogether 729 *Buccinum* on 354 m², or ca. 2 *Buccinum* are found per m².

Owing to the difficulties of the diving operations on soft bottom, we kept him to the less soft, where we know that most *Buccinum* are found; owing to this probably we got a number somewhat greater than that given by the bottom-sampler, namely 2 instead of 1,3 per m². Whichever number we take as basis for a calculation of the number of *Buccinum* living in Thisted Bredning, we find great quantities of whelks there.

Outside the 6 meter line the area of Thisted Bredning is, namely, ca. 65 million m²; consequently, we find either 84,5 millions or 130 millions of these whelks on the whole area, in addition to the smaller whelks *(Nassa)* which are ca. 5 times more numerous.

If we reckon in round numbers with 100 millions of *Buccinum*, this gives ca. 19,131 barrels = 26,754 hectol., as 5,200 *Buccinum* on an average make one barrel. In comparison with such numbers, the quantity fished by us in 1910, 480 barrels, is obviously quite insignificant; the stock is easily able to replace the number of whelks fished, if that is to say the conditions for their growth are present.

Professor W. Johannsen has kindly undertaken a numerical revision of the numbers found by means of the large bottom-sampler (1,2 m²) and has given me the following information about the result. The number of *Buccinum*, 1,3 per m² or ca. 85 millions, found in Thisted Bredning outside the 6 meter line in October

1909, has an average error of 16 millions. When twice the average error is taken as range, this gives as outer limits respectively 53 and 117 millions. It is but little probable that the size of the stock lies outside these limits. The number of *Buccinum*, 480 barrels or ca. 2,5 millions, taken by the fishery in 1910, only represents consequently $^1/_{34}$th of the calculated quantity of the stock. And even in the most favourable case with regard to the importance of the catch, that the real size of the stock is at the lowest of the limits above-mentioned, the catch is only $^1/_{21}$; but this case is not more probable than the opposite, that the real size of the stock is at the upper limit, and in this case the catch is but $^1/_{47}$th of the stock.

The result of these calculations thus gives us, that the number of *Buccinum* fished in 1010 is but a small part of the stock of whelks, and it may be said, further, that great quantities of *Buccinum* live in near the shores, where it has not been possible to obtain samples with the bottom sampler; these quantities have not at all been included in any of these calculations.

There is reason to believe, however, that the quantity of whelks was not quite as great in 1910 as in 1909; on the one hand, the 0,1 m^2 bottom-sampler used at 200 stations did not take as many *Buccinum* in 1910 as in 1909, and on the other, the catch in the whelk-traps was not so great in 1910 as I had reason to expect from 1909. In 1909 34 traps were taken up 7 times from the 8.—16. October, and had consequently been out as a rule but 24 hours each time; 69 half-bushels in all were fished. This makes 0,29 half-bushels per trap per day. In the beginning of October 1910 from the 3.—17., however, the traps which were now out for 2 to 3 days gave but 0,19 half-bushels per trap each time; thus not nearly so many; during this period no less than 1175 traps were examined. The two grounds fished on lie near together; but it must be admitted, that it is difficult to draw any definite conclusions from this material, as even a short distance can affect the result, and in addition to this the nature of the bait may also be of importance; both series of data however indicate the same, namely, smaller quantities of whelks in 1910 than in 1909. The statements of the fishermen are also in accordance with these results. The whelks have not been so bad in 1910 as in the year before; they have especially not damaged the fishes in the nets so much in 1910 as in 1909.

In 1908 an unusual number of small and large cod immigrated into Thisted Bredning and probably into the whole Limfjord, it seems also, into the whole of Denmark; people could be seen trailing for cod in and outside Thisted harbour in 1909 during the whole of the summer, something not known there usually, and in 1910 the cod were still there. As these cod grew larger they could devour the *Buccinum*; and the contents of their stomachs distinctly show that they do so on a large scale. In a cod of $^1/_4$—$^1/_2$ a kg. the soft parts with operculum of as many as 6--7 *Buccinum* were often found. It is remarkable that the shells themselves of the whelks are seldom seen in the cod. I have only seen this outside the Limfjord; a half digested and almost transparent shell was all that was left. As we know how firmly the whelk is attached to its shell, we cannot doubt that the cod must swallow the shell to get the soft parts; the latter are not digested until the gastric juices have dissolved the shell. It is possible that the shells are so seldom found in the somachs because I have only

investigated the latter in the daytime; probably the cod in the Limfjord feed in the nighttime. However the case may be, many *Buccinum* have been devoured by the cod in 1909 and 1910; and I consider it probable, that we have here the reason of the smaller quantity of the whelks in 1910. To judge from the results of the small bottom-sampler, the numbers of *Nassa* on the other hand have not decreased; I have never seen them more numerous than in the spring of 1910; but so far as known *Nassa* is not sought after by cod or by other animals in Thisted Bredning, so far as I know. Its shell is stronger than that of *Buccinum*.

It is quite possible, however, that the supposed reduction in the numbers of *Buccinum* is also due to other causes than the attacks of the cod. *Buccinum* belongs to the molluscs whose young do not float about in the water; they remain at the bottom when they have crept out of the egg-capsule; but in spite of eager search in these years we have only succeeded in finding extremely few, fully developed young in the otherwise very numerous egg-masses, which *Buccinum* every spring deposits on stones and shells in the Bredning. Nor have we been able to find, with but few exceptions, the small, fully developed, free-living young on the bottom, where however there must be many per m^2, even if only one comes out of the many egg-capsules. Later in the summer, however, many eggs are found dead and not developed in the capsules and many seem to be attacked by fungi or bacteria; it is probably not unreasonable to suppose that epidemics may arise, where so many *Buccinum* live so close together. In any case the small number of quite small *Buccinum* in the Bredning is remarkable. The whelk seems to take several years before it reaches its full size, thus to grow slowly; if there is not a sufficient augmentation from the side of the young, the stock will be appreciably reduced in the course of some years.

It is said, that these whelks have spread very much in the Limfjord during the last 10—20 years; that they first appeared in the western parts of the fjord, where they are now less numerous, whilst the central parts of the fjord are now teeming with them. If this is really the case, that they have been numerous in the western parts, e. g. in Kaas Bredning, we may indeed hope, that they will also to some extent disappear in the central parts; in the western parts, at any rate, they are not nearly so troublesome as elsewhere, and their number is obviously much fewer per m^2 there. It is chiefly to the west and north of Mors and in Livø Bredning, that they are now so numerous.

I may also mention here one thing more regarding the biology of *Buccinum*. As I can scarcely believe, that the dead fishes and on the whole the dead animals which fall to the bottom, can provide sufficient food for these whelks, I have tried to find out what they live on from the *Buccinum* we caught; but I have always found but small quantities in their stomachs and always only some indeterminable slime; what they feed on normally in the Limfjord, therefore, I do not know; but everything thrown out, dead fish, dead oysters etc. are attacked by them at once, so long as it is fresh. They know probably how to find similar food not only among dead animals; they probably also know how to attack the living animals, such as small mussels etc. How the large whelks can open mussels is in fact well-known; I may refer here to a paper by H. S. Colton

(Proceedings of the Acad. of Nat. Sc. of Philadelphia 1908. Jan. pp. 3—10 with 5 Plates), which explains, how the larger whelks can open large mussels and eat them.

That it is the month of June especially, which shows the greatest numbers of whelks caught, is certainly connected with the fact, that at this time the majority of the whelks have just deposited their eggs; and it is a well-known phenomenon, that for many species of animals the feeding time as a rule succeeds the spawning time. —

If now we are not disposed to believe, that the whelks of themselves will decrease in numbers, then the above investigations indicate clearly, that June and a part of July are especially the months when they might be fished for with the greatest success by means of the hive-traps. It is possible indeed that we might be able to find a still better method of fishing them; but so long as we do not know of such a method, we cannot take it into consideration. As we must remember, that the quantities of the whelks in Thisted Bredning amount to at least ca. 20,000 barrels, it will probably not be of any use to fish less than about the half or third during the year, and it must also be remembered, that the fewer the whelks become, it will be so much the more difficult to get many of them. In other words, about 74 or 50 times more whelks must be fished in the month of June than the motor-boat has taken this past year in June; or if we also include July in the fishing period, 25—40 boats must work just as hard in two months as this one boat has worked. If we imagined, that the fishermen in Thisted would spend 1 to 2 months in fishing whelks with a subvention from the State of 2 Kr. per barrel of whelks fished, the expense would amount to 10 to 20,000 Kroner per year, thus much more than the inplanting of plaice in Thisted Bredning costs. It would thus be much better to inplant more plaice into the Bredning, if this can support more than the 60 per hectare it now gets. It is so difficult to combat the whelks even in Thisted Bredning alone, so long as we have not found any other method of fishing whioh can perhaps give other results, or until we have found some profitable use for the whelks themselves, so that the fishery would at least for a great part pay itself. And yet we must consider these whelks *(Buccinum)* as much easier to combat than other animals, which might in masses suddenly come wandering into the fjord or as young drift in with the current (star-fishes), or as adult swimming fish (sticklebacks). I am inclined to believe, that the fight against the harmful animals of the fisheries is much more difficult than is usually imagined; but one thing is certain, the matter must be investigated separately for each single species and regard taken of the methods of capture available at the time and the possible methods of making use of the products. These investigations show to the full, how useless is the system of rewards for the whelks brought on land on a small scale. It would be much more profitable to think out some way of avoiding the damage the whelks do, by giving the fishermen the right to make certain regulations with regard to the gill-net fishing especially in the warm months, as for example, that the interval between the times the nets are taken up should not be too long; I have often heard wishes put forward by the fishermen on this matter; but I need not enter further into this

side of the question; when the fishery laws come eventually to be revised however, this question should not be forgotten.

It was my intention, as mentioned, to follow a plan in these investigations, which would give a positive answer in the course of time, as to whether it would be of use to do this or that, or whether it would be useless, instead of blindly beginning a series of undertakings, which however long they may be continued, would give no answer (premiums). I believe that I have carried through the plan as well as the circumstances for the present permit. If new moments of importance should appear in the future, the question could always be taken up again; we now know a good deal more regarding the whelk question in the Limfjord than before these investigations were begun; thus, we know, that it might well be within the power of the State to exterminate almost all the *Buccinum* in Thisted Bredning in the course of some years, but we also know, that the money would be badly spent, we should rather use a portion of it on more extensive inplanting of plaice in the Limfjord. As is known, the State has experimentally given out enormous sums for the collection and distruction of the May bugs, with the result that the May bugs have now almost disappeared; but as Professor I. E. V. Boas writes in his book on the May bug in 1904, their disappearance is not due to their collection, but to the attacks of their natural enemies (bacteria). I believe that we have reason to hope, that the same will happen with the whelks (Konkylierne) in the Limfjord.

I have very often pointed out, that man can do much to reduce the numbers of a species in the sea, and can also often manage to make their numbers very few, e. g. the prawn in Denmark. But what has this cost, both in work and money? — In the good years for the prawn in the Limfjord in 1895 and 96, the value of the traps and purse-nets amounted to ca. 50,000 Kr.; the value of the boats and the work is not included; but hundreds of fishermen were occupied in the fishery. When so much energy is being used, much can be done; it succeeded; in 2—3 years the prawn became more scarce, and is so still; it paid the expense with 70—80,000 Kroner per annum, and between 100 and 200 thousand pounds were fished yearly of these animals in the Limfjord; and the fight against the few remaining still continues whenever the opportunity presents itself. I certainly believe that it would be much easier to reduce the numbers of the whelks in the Limfjord; but I must consider the sums necessary for this purpose as badly used, — at any rate, so long as no new, unknown moments appear, which might considerably facilitate the fishing and reduce the expense.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen 1888. 8°. 1162 pg. 2 Kort.

Det videnskabelige Udbytte af Kanonbaaden »Hauch«s Togter i de danske Have indenfor Skagen. 1893. 4°. 464 pg. Atlas i folio.

Indhold: Echinodermata (Petersen), Diatomeer (Cleve), Undersøgelse af nogle Bundprøver (Rørdam), Mollusca (Petersen), Cephalopoda (Posselt), Crustacea malacostraca (Meinert), Hydrografi (Rørdam), Polyzoa (Levinsen), Ascidiæ simplices (Traustedt), Annulata, Hydroidæ, Anthozoa, Porifera (Levinsen), Nogle alm. Resultater (General Results. Engl.) (Petersen).

C. F. Drechsel: Oversigt over vore Saltvandsfiskerier med Kort og Planer. 1890. 4°, 100 pg. Med et Tillæg: »Om Naturforholdene indenfor Skagen« af *C. G. Joh. Petersen.* Med Kort. 4°. 46 pg.

Fiskeri-Beretning for 1888—89, 89—90, 90—91, 91—92, 92—93, 93—94, 94—95. 95—96, 96—97, 97—98, 98—99, 99—1900, 1900—01, 1901—02, 1902—03, 1903—04, 1904—05, 1905—06, 1906—07, 1907—08. 1908. 1909.

Beretninger fra den danske biologiske Station findes paa dansk publicerede i de tilsvarende Fiskeri-Beretninger.

I. Fiskenes biologiske Forhold i Holbæk Fjord. 1890—91. 63 pg. Med et Kort.
II. Om vore Kutlingers (*Gobius*) Æg og Ynglemaade. 1892. 9 pg. Med 2 Tavler.
II. On the Eggs and Breeding of our Gobiidæ. 1892. 9 pg. Two Plates.
III. Det pelagiske Liv i Fænø Sund etc. 1893. 38 pg. Tabeller.
III. The Pelagic Life in Fænø Sound etc. 1893. 38 pg. Tables.
IV. Om vore Flynderfiskes Biologi og om vore Flynderfiskeriers Aftagen. 1894. 146 pg. 2 Tavler. 1 Kort og mange Tabeller.
IV. On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. 1894. 146 pg. 2 Plates. 1 Chart. Many Tables.
V. Den alm. Aal (*Anguilla vulgaris* T.) anlægger før sin Vandring til Havet en særlig Forplantningsdragt. 1896. 35 pg. Med 2 Tavler.
Etc. 64 pg.
V. The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. 1896. 35 pg. With 2 Plates.
Etc. 64 pg.
VI. Om Rødspætteyngelens aarlige Indvandring i Limfjorden etc. 1887. 49 pg. 1 Kort. 2 Tabeller.
VI. The Yearly Immigration of young Plaice into the Limfjord etc. 1897. 48 pg. 1 Chart. 2 Tables.
VII. Plankton-Studier i Limfjorden. 1897. 23 pg. 1 Kort. 4 Tabeller.
VII. Plankton Studies in the Limfjord. 1897. 23 pg. 1 Map 4 Tables.
VIII. Om et Skovl-Vaad til Undersøgelse af dybere Farvande. 1898. 24 pg. 10 Figurer.
VIII. An Otter-Seine for the Exploration of Deeper Seas. 1898. 24 pg. With 10 Figures.
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XIV. I. Om Lysets Indflydelse paa Aalens Vandringer. II. Om Aalens Alder og Vækst. 1906. 39 pg.

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XV. I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pg.)

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XVI. On the Ecology and Distribution of the Grass-Wrack *(Zostera marina)* in Danish Waters. (With 9 figures.) 1908. 62 pg.

XVII. Studier over Østersfiskeriet og Østersen i Limfjorden. 1908. 24 pg.

XVII. II. Second Report on the Oysters and Oyster Fisheries in the Lim Fjord. 1908. (24 pg.)

XVIII. I. Om Udbyttet af Limfjordens Fiskerier i de senere Aar samt om Rødspætteindplantningen i 1908. Med 6 Tabeller og 1 Kort. II. Biologiske Undersøgelser over Limfjordens Rødspættebestand. Med 3 Tabeller. III. Om Rejefiskeriets Udbytte fra 1885—1907 og om dets Forbedring ved Fredning. Med 3 Tabeller. 25 pg.

XVIII. I. The Yield of the Limfjord fisheries in recent years and the transplantation of plaice in 1908. With 6 tables and 1 chart. II. Biological investigations on the stock of plaice in the Limfjord. With 3 tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 tables. 25 pg.

XIX. Nogle Undersøgelser over Muligheden af at bekæmpe Fiskeriets Skadedyr, særlig Sneglene i Limfjorden. 1911. 20 pg.

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